MECHANICAL PROPERTIES OF POLYMER

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WHAT IS POLYMER...???

A polymer is a large molecule made up of chains or rings of linked repeating subunits, which are called monomers.

Ex:

1) Natural Polymers:
   Hemp, Shellac, Wool, Silk, Rubber

2) Synthetic Polymers:
   Polyethylene, Polypropylene, Polystyrene, Polyvinyl Chloride, Synthetic Rubber, Phenol Formaldehyde Resin, Neoprene, Nylon, Polyacrylonitrile, PVB, Silicone
It is of great importance to be familiar with some basic mechanical properties of the material before its application in any field, such as how much it can be stretched, how much it can be bent, how hard or soft it is, how it behaves on the application of repeated load and so on.

These basic structural properties play a major role in determining bulk physical properties of the polymer, which describe how the polymer behaves as a continuous macroscopic material.
PROPERTIES OF POLYMER

1) Mechanical Properties
2) Thermal Properties
3) Optical Properties
4) Electrical Properties
5) Chemical Properties
The most important mechanical property for polymeric material is the determination of its stress-strain curve in tension.

The normal stress-strain curve for plastics shown in figure in next slide.

This type of curve is typical of plastics such as Polyethylene.

It defines useful quantities such as modulus, yield stress, strength, elongation at break.
Stress vs Strain

- Tensile strength
- Yield strength
- Modulus (results as stiffness)
- Toughness
- Elongation at yield
- Plastic behaviour, is there any?
- Elongation at break
1) Yield stress: “It is the material property defined as the stress at which a material begins to deform plastically and stop to behave elastically.”

2) Ultimate Strength: “It is measured by the maximum stress that material can withstand by being stretched or pulled before breaking.”

3) Elongation at break: “Elongation at Break, also known as fracture strain or tensile elongation at break, is the ratio between increased length and initial length after breakage of the tested specimen at a controlled temperature.”
Tensile stress-strain curve for several types of polymeric materials
b) Fatigue Tests

- **Fatigue testing** is defined as the process of progressive localized permanent structural change occurring in a material subjected to conditions that produce fluctuating stresses and strains at some point or points and that may culminate in cracks or complete fracture after a sufficient number of fluctuations.
- A fatigue test is also used for the determination of the maximum load that a polymer sample can withstand for a specified number of cycles.
Apparatus of Fatigue Test

- Fatigue is a form of failure that occurs in structures subjected to dynamic stresses over an extended period.
- Under these conditions, it is possible to fail at stress levels considerably lower than tensile or yield strength for a static load.
- Single largest cause of failure in metals; also affects polymers and ceramics.
- Common failure in bridges, aircraft and machine components.
c) Impact Tests

- The **impact test** is a method for evaluating the *toughness and notch sensitivity* of materials.
- It is usually used to **test** the toughness of metals, but similar tests are used for *polymers*, ceramics and composites.
- Impact strength of plastics is measured by tests in which a pendulum with a massive striking edge is allowed to hit the specimen.
- Other forms of impact test include a large variety in which falling objects strike the specimen.
Apparatus of Impact Test
d) Tear Resistance

- **Tear resistance** is a measure of how well a material can withstand the effects of tearing.

- Substances with high tear resistance include natural rubber and polyurethane. In contrast, materials such as silicone and fluorosilicone have low tear resistance.

- When plastics are used as films, particularly in packaging applications, their resistance to tearing is an important property.

- Tear strength and Tensile strength are closely related.
e) Hardness

Resistance to permanently indenting the surface.

Large hardness means:
- resistance to plastic deformation or cracking in compression.
- better wear properties.

Examples:
- 10 mm sphere: apply known force, measure size of indent after removing load.

Smaller indents mean larger hardness.

Materials:
- most plastics
- brasses
- Al alloys
- easy to machine steels
- file hard
- cutting tools
- nitrided steels
- diamond
The application of hardness testing enables you to evaluate a material's properties, such as strength, ductility and wear resistance.

### Mohs Hardness Scale

<table>
<thead>
<tr>
<th>Mineral Name</th>
<th>Scale Number</th>
<th>Common Object</th>
</tr>
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<tbody>
<tr>
<td>Diamond</td>
<td>10</td>
<td>Masonry Drill Bit (8.5)</td>
</tr>
<tr>
<td>Corundum</td>
<td>9</td>
<td>Steel Nail (6.5)</td>
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<tr>
<td>Topaz</td>
<td>8</td>
<td>Knife/Glass Plate (5.5)</td>
</tr>
<tr>
<td>Quartz</td>
<td>7</td>
<td>Copper Penny (3.5)</td>
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<tr>
<td>Orthoclase</td>
<td>6</td>
<td>Fingernail (2.5)</td>
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<tr>
<td>Apatite</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Fluorite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>3</td>
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</tr>
<tr>
<td>Gypsum</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Talc</td>
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</table>
f) Abrasion Resistance

- Abrasion Resistance in plastics usually takes in the form of scratch test, in which material is subjected to many scratches, usually from contact with an abrasive wheel or a stream of falling abrasive material.

- The degree of abrasion can be determined by loss of weight for severe damage, but is more usually measured by evidence of surface marring, such as loss of gloss or development of haze in transparent specimens.
Apparatus for Scratch Test

Diagram showing the apparatus for a scratch test, including:
- Normal load
- Diamond stylus
- Coating layer
- Frictional force
- Sample motion
- Substrate

Lc1 and Lc2 labels indicate specific areas on the sample.
THANK YOU